 

Technical Report:

The Ecological Footprint of Slovenia

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Advancing the Science of Sustainability

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1. Introduction

This technical report establishes baseline knowledge on the history, drivers, and contributions of consumption sectors to Slovenia's Ecological Footprint. It creates the foundation upon which to identify and inform targeted Footprint reduction policies to meet the goals of Slovenia's National Development and Environment strategies. In Phase II, findings from this technical report will guide quantitative assessments of potential Footprint reductions that can be achieved in Slovenia by 2030, both by sector and for the country.

The report begins with an overview of the Ecological Footprint and current trends in global sustainability. We then examine historical (1992-2014) and projected (2015-2018) trends of Slovenia's Ecological Footprint and biocapacity, followed by a sectoral analysis of the Ecological Footprint of consumption. Next, we assess Slovenia's progress towards sustainable human development by combining the information derived from Ecological Footprint accounting with UNDP's Human Development Index. The report concludes by assessing the potential for the Ecological Footprint to inform and/or contribute to Slovenia's National Environmental Action Programme 2030 and Development Strategy 2030.

2. The Current Situation: Ecological Footprint and the Global Context

Managing sustainability is ultimately a question about the earth's capacity to support human societies. Living within the means of one planet is the starting point to creating a future society where all people can thrive. *One Planet* is not a goal, but a reality which we must acknowledge and manage. Given that we live on one planet, *how can policy makers guide our transition into the future* considering humanity is already demanding more than Earth's ecosystems can renew? How do we serve an expanding global population harbouring legitimate growth aspirations (as put forth in the Sustainable Development Goals), while phasing out fossil fuels within a few decades (as promised in the Paris Agreement developed at COP21), and protecting the integrity of the planet's ecosystems and biodiversity (as intended through the Aichi Biodiversity Targets)?

A country cannot manage what it does not measure. To measure the current resource demand (by the Slovenian economy or its residents) and supply (from Slovenian ecosystems or the world) as well as the historical evolution of these parameters, the Ecological Footprint was recently adopted as a Strategic Indicator for the both the Slovenia's Development Strategy 2030 and the draft National Environmental Action Programme 2030.

The Ecological Footprint (EF) is one of the most widely used and recognised integrated sustainability indicators for human pressure on ecosystems (Wackernagel et al., 2002; 2018). It measures the renewable natural resources and ecological services demanded as a result of a population's consumption activities and compares that to what ecosystems are capable of providing. It provides a unique framework to compare different productive sectors or consumption activities within an economy in terms of the pressure they generate on the environment. Framing the environmental pillar of sustainability with an overarching metric such as the Ecological Footprint informs users of the overall human demand on ecosystems (Mancini et al., 2018) while breaking Ecological Footprint into sectors allows decision makers to highlight inefficiencies and set actionable targets for Footprint reduction (Galli, 2015). Nonetheless, sustainability is a context-dependent and trans-disciplinary issue and no single metric exists that alone can address the full complexity of sustainability (Bossel, 1999; Galli et al., 2012; Moldan et al., 2012; Moreno Pires, 2014; Singh et al., 2012).

The Ecological Footprint of Countries

Global Footprint Network calculates the Ecological Footprint of over 200 countries, regions, and the world with historical data reaching back to 1961 (GFN, 2018). For a given country, the Ecological Footprint measures the ecological assets (i.e., the biologically productive land and sea areas) required by the population of that country to produce the natural resources and services it consumes. This includes plant-based food and fibre products, livestock and fish products, timber and other forest products, waste absorption (CO_2 from burning fossil fuels), and space for urban infrastructure. This is compared to the biocapacity of that country – a measure of the ecological assets available within national borders (including forest lands, grazing lands, cropland, fishing grounds and built-up land) and their capacity to provide ecological services (Borucke et al., 2013; Galli et al., 2014; Wackernagel et al., 2018). Ecological Footprint and biocapacity are expressed in global hectares (gha), a unit representing area of world-average productivity (Galli, 2015).

By dividing the total Ecological Footprint of consumption[1] of a country by the total population, we get the average per person Ecological Footprint, which reflects the amount and types of goods and services used per person in that country (Bastianoni et al., 2013; Wackernagel et al., 2018). Currently, carbon uptake is the largest single Footprint component, representing more than 50% of the Ecological Footprint for almost half of all countries.

The ecological balance of a country can be determined by comparing a country's consumption of natural resources and services – its Ecological Footprint – to the capacity of its natural assets to supply them – its biocapacity. An ecological deficit occurs when the Ecological Footprint is greater than the biocapacity of the country (Monfreda et al., 2004). Three possible situations contribute to a country's ecological deficit: 1) a country can import the biocapacity that it consumes but does not produce; 2) a country can overharvest its own resources for a time through unsustainable agricultural practices, overgrazing, overfishing, or deforestation, and 3) a country can emit more CO_2 in the atmosphere than it has the capacity to sequester (Niccolucci et al., 2011). As such, many countries can operate with an ecological deficit without drawing down their own stocks of natural capital. By importing biocapacity from other nations and by exploiting the global commons, a country can consume more than their local ecosystems can renew without degrading or depleting their local biocapacity (Niccolucci et al., 2011; 2012); nonetheless, such a strategy can expose the national economy to external, trade-related risks such as commodity price volatility (Galli et al., 2015; Wackernagel and Galli, 2012).

Globally, most countries overdraw their own biocapacity for export while simultaneously importing additional biocapacity from somewhere else (Galli et al., 2014; Steen-Olsen et al., 2012; Weinzettel et al., 2013). This has led to significant national biocapacity deficits and a global ecological overshoot—since the 1970s, humanity's Ecological Footprint has surpassed the Earth's biocapacity to the point where approximately 1.7 Earths are required to provide the regenerative capacity consumed by humanity in a single year (Figures 1 and 2). The loss of natural capital through deforestation and overfishing, accumulation of CO_2 in the atmosphere, and transgression of planetary boundaries are all manifestations of ecological overshoot (Catton, 1980; Odum, 1997), a transnational and cross-cutting

[1] The Ecological Footprint of consumption of a country is adjusted for trade by adding the Ecological Footprint embedded in imports and subtracting the Ecological Footprint embedded in exports.

challenge that must be monitored holistically and addressed through international cooperation and global efforts, like the Paris Agreement, the Aichi Targets and the Sustainable Development Goals.

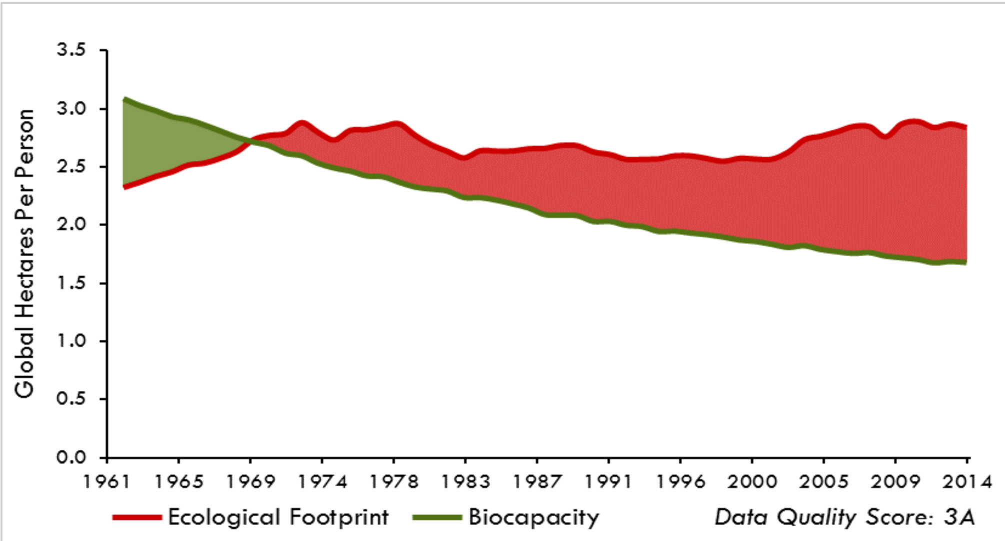

Figure 1. Ecological Footprint and biocapacity per capita for the World, 1961-2014. In 2014, humanity's per capita Footprint and World biocapacity were 2.8 gha and 1.7 gha respectively. Since the early 1970s, humanity's annual demand on Earth has exceeded what the planet can renew. This ecological overshoot has steadily grown during the past 40 years, to the point that it now takes 1.7 Earths to regenerate the resources we use each year.

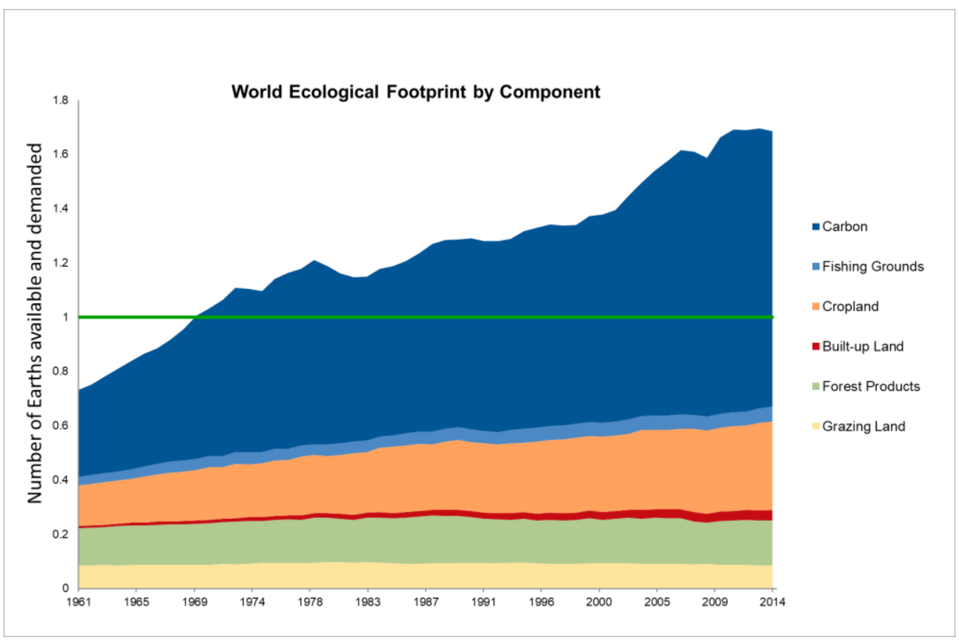

Figure 2. Contribution of land use types to global Ecological Footprint from 1961 to 2014. Ecological Footprint values in this graph are normalized to World biocapacity (indicated by the green line). In other words, the Ecological Footprint here is measured in number of Earths rather than in global hectares.

3. Slovenia's Ecological Footprint and biocapacity by land-use type

Ecological Footprint results for Slovenia indicate that, as of 2014, an average resident of Slovenia demanded 4.7 gha of bioproductive land to support their lifestyle (Figure 3). Such demand is consistent with the EU average (also 4.7 gha per person), and 65% higher than the world average of 2.8 gha per person. This value is also more than two times higher than Slovenian biocapacity (2.3 gha per person).

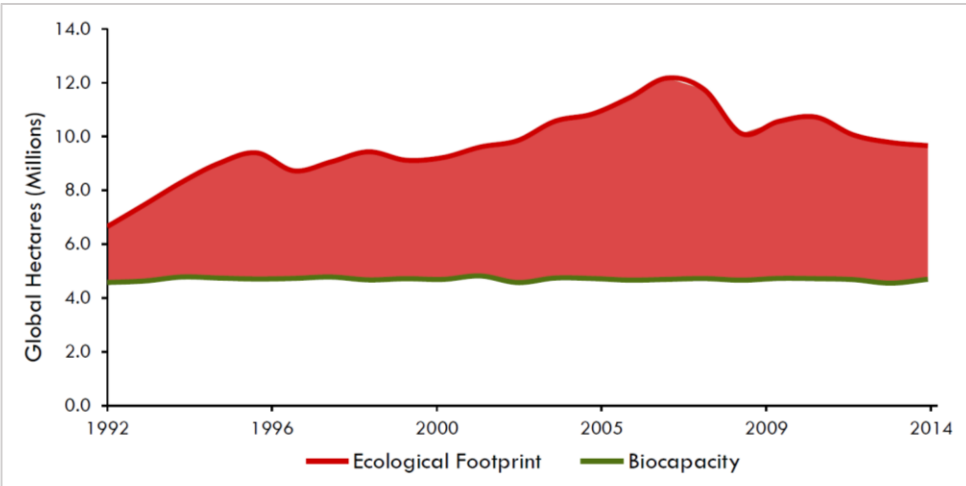

Figure 3. Trends in total Ecological Footprint and biocapacity in Slovenia from 1992 to 2014.

In the 5 years immediately after national independence, the Ecological Footprint of Slovenia increased steadily, most likely the results of 1) a gradual, state-centred structural and economic transition put in motion after the dissolution of Yugoslavia, 2) continued favourable conditions such as low cost of labour and raw materials (mainly imported from the rest of the former Yugoslav Federation), 3) active economic and trade relationships with Western Europe (e.g., Austria, Germany and Italy), and 4) a relatively minor impact from the war (Fabbri, 2016). A second phase of increase in the Ecological Footprint of Slovenia was found in the 4-5 years immediately after Slovenia accession to the EU in 2004 – a trend also seen in other countries such as Portugal and Spain – possibly as a consequence of increased public and private investment, low tax on fuels and increased road transport after entering in the EU, which likely pushed consumption upwards. In 2008-2009 the economic downturn that has affected most of the EU countries yielded a sudden drop in the Ecological Footprint of Slovenia due to contraction in consumption, although such drop was not as prominent as in Greece and Italy, for instance (see Galli et al., 2015). This period also coincided with high price of oil combined with an increase in excise tax on fuels. Ever since 2010, Slovenia has been characterized by a relatively stable EF: Slovenia's Ecological Footprint was 4.7 gha per person in 2014, corresponding to an equivalent of 2.8 Earths worth of resources to support the world population if all people on Earth lived like an average Slovenian.

Meanwhile, Slovenia's biocapacity is relatively high compared to other EU countries and likely due to natural endowment of local forests and natural protection policies.

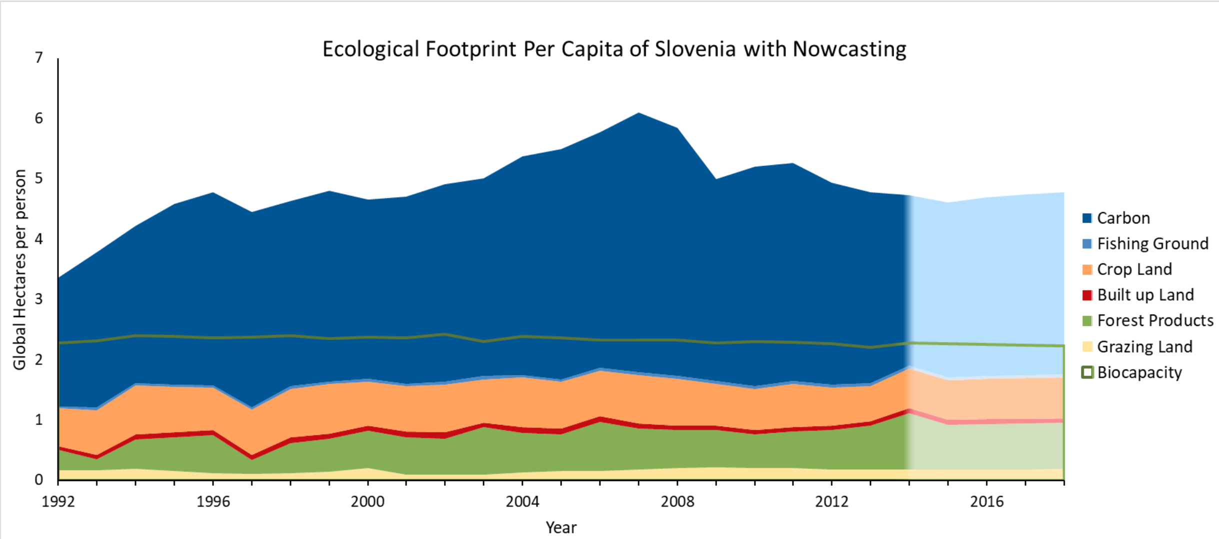

Figure 4. Slovenia's Ecological Footprint of consumption by land type from 1992 to 2018. Note: 2015-2018 values are nowcasted. See Appendix 1 for nowcasting methodology.

The Footprint breakdown by land type (Figure 4) indicates that—in line with the average EU-28 Footprint—the carbon component represents 60% of the Slovenia's Ecological Footprint, followed by a demand for forest products (20%) (11% for EU-28) and cropland (14%) (19% for EU-28) in 2014 (see Figure 5 for a comparison of Slovenia's Footprint with EU-28 and select EU countries).

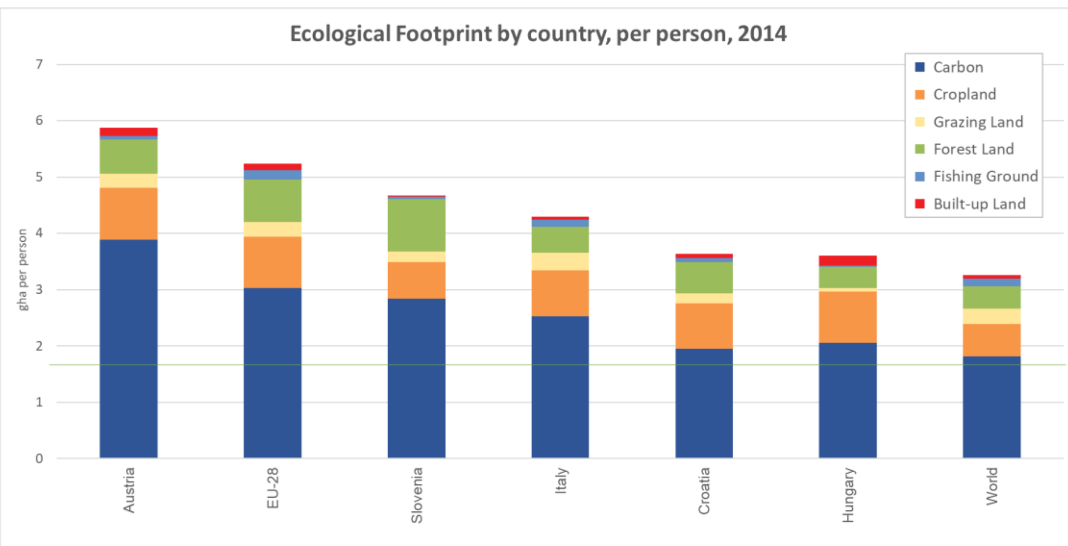

Figure 5. A comparison of the Ecological Footprint of consumption by land type in 2014, measured in global hectares per person, between Slovenia, select countries, the European Union, and the World.

As described in Borucke et al. (2013), Ecological Footprint assessments are conducted on the basis of data from several UN and other international agencies. Given the lack of comprehensive official data for the post-2014 period, a nowcasting technique (see Appendix 1 for further details) has been here used to estimate Ecological Footprint values up to the current year. Nowcasting results indicate no significant change in Slovenia's per person Footprint for any land type except carbon, which is estimated to have grown by 7% from 2014 to 2018.

4. Sectoral Analysis of Ecological Footprint of Consumption

Footprint results do not usually show which economic activities are demanded but rather the consequences, in terms of land appropriation, of demanding the outputs of economic activities (Mancini et al., 2018). However, attributing the overall demand on nature to particular human activities is essential to then be able to act upon such demand and requires an additional analytical step beyond basic Ecological Footprint accounting (Galli, 2015). For specific study at the national level, Environmentally Extended Multi Regional Input-Output Analysis can be applied to derive Ecological Footprint values broken down into major categories of consumption[2] (Weinzettel et al., 2014; Wiedmann et al., 2006). This is done by calibrating National Footprint Assessments data with Multi Regional Input-Output (MRIO) tables from the Global Trade Analysis Project (GTAP) database[3]. The result is a Consumption Land Use Matrix (CLUM) for the country under study. (See Appendices 2 and 3 for details on MRIO and CLUM methodology, respectively).

Since statistical offices track how households, government and industry spend their money, we can use these estimates to translate land-based Ecological Footprint results into activity-based Ecological Footprint results. This is called the Consumption Land-Use Matrix, or "CLUM". The final demand categories are:

1) consumables paid for by households;
2) consumables paid for by government, such as school supplies in public schools, police equipment, and paper for public administration; and
3) lasting goods and assets, or "gross fixed capital formation", such as construction of buildings, roads, factories, and associated equipment.

This analysis combines the Footprint of the final demand categories (household, government spending, and gross fixed capital formation) and breaks down the total into five major consumption categories: food, housing, transport, goods, and services. For each consumption category, we calculated the Ecological Footprint on six different land use types (built-up land, forest land, fishing grounds, grazing land, cropland and carbon) resulting from final purchases in each consumption category (Galli et al., 2017).

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[2] The Classification Of Individual Consumption According to Purpose (COICOP) is the internationally agreed classification system for reporting household consumption expenditures. It is published by the United Nations Statistics Division for use in expenditures classification, National Accounts, Household Budget Survey and the Consumer Price Index.

[3] Global Trade Analysis Project (GTAP 9 Data Base) consists of 57 sectors – 12 of which are agricultural – and includes 140 countries and regions (Narayanan and McDougall, 2015).

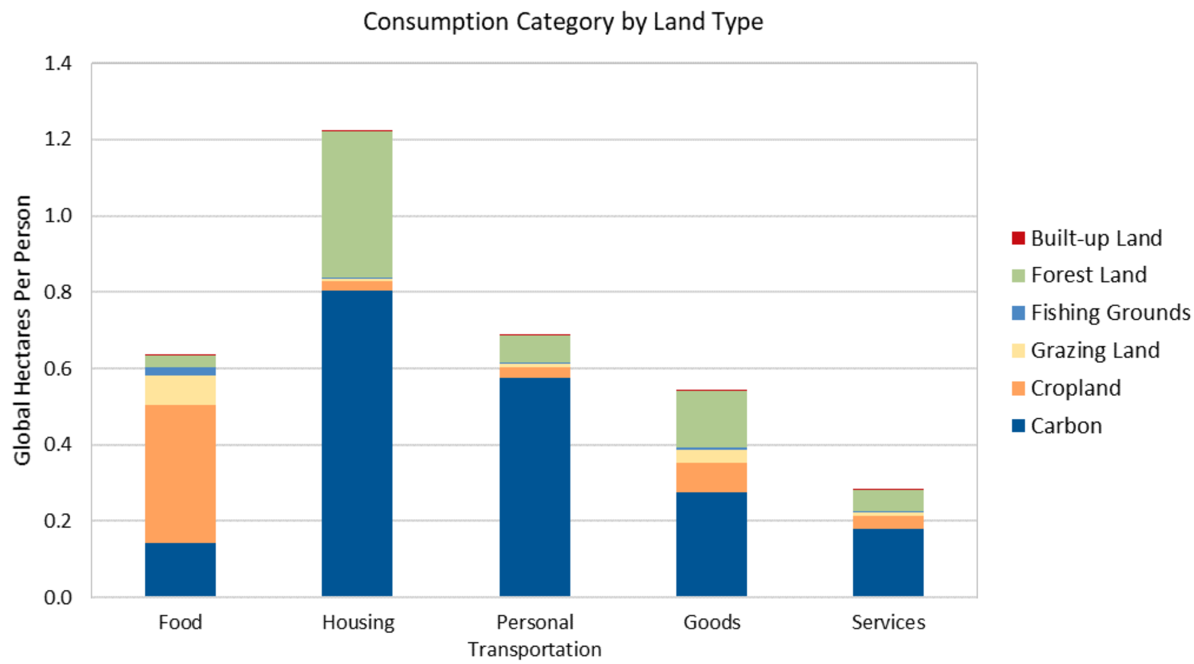

Figure 6. Ecological Footprint of consumption by land type across the five consumption categories for Slovenia, 2014.

Here, we focus on the household component (Government and Gross Fixed Capital Formation results can be seen in appendix 4). The breakdown of the Ecological Footprint by consumption activity (Figure 6) indicates that housing is the primary driver (36%) of household Ecological Footprints of Slovenia. Furthermore, the carbon Footprint accounts for 60% of Slovenia's total Ecological Footprint of consumption. Roughly 24% of the Footprint comes from the carbon Footprint of housing alone, thus pointing towards energy efficiency in residential building as one of the key hotspots and entry points for Footprint reduction in Slovenia. In addition, the carbon Footprint from personal transportation accounts for 14% of Slovenia's total Ecological Footprint. The amount of forest product Footprint within the housing category is alto notable: at 0.4 gha per person it makes up 11% of the total household Footprint (see Appendix 4 for a detailed table of Slovenia's CLUM results). Overall, carbon is the largest contributor to the Footprints of each consumption category except for food, where cropland is the highest. As found by Galli et al. (2017), Slovenia has the lowest per capita food Footprint value among all the Mediterranean countries, due to a diet low in animal proteins and rich in cereals and vegetables.

5. Slovenia's progress towards sustainable human development

Since the 1992 Rio Summit and the publication of Agenda 21, many indicators, indices, and dashboards have been proposed stimulating political, academic, scientific, and community debates on the best way to assess and operationalize sustainable development (Hak et al., 2016; Pulselli et al., 2016). Despite the proliferation of indicators during the last two decades, consensus on how to measure sustainable development has started to exist only in very recent years thanks to the identification of a global SDG indicator framework by the IEAG-SDGs (Sachs, 2012). Despite this initial consensus, many still point out the lack of systems thinking in our societal attempt to articulate and measure sustainable development (Galli et al., 2018) and the need for an overarching sustainability goal which Costanza and colleagues define as "a prosperous, high quality of life that is equitably shared and sustainable" (Costanza et al., 2014).

In an attempt to address such gap, thus providing an overarching measure of progresses towards sustainability, we propose national progress toward sustainable development to be assessed by comparing the Ecological Footprint to the United Nations' Human Development Index (HDI), which aggregates education, longevity and income into a single metric (UNDP, 2016).

The United Nations Development Programme (UNDP) defines an HDI score of 0.7 as the threshold for high development. The biocapacity available on the planet is calculated as 1.7 gha per person. Combining these two thresholds gives clear minimum conditions for globally sustainable and replicable human development. Countries in the light-blue section of the lower right-hand box (Figure 7) exhibit high levels of development within globally sustainable resource demand levels.

Slovenia has experienced great progress in human development, advancing from an HDI score of 0.77 in 1992 to 0.89 in 2014, pushing the country across the threshold from a 'high' to 'very high' level of human development. This was not without an accompanying increase in Ecological Footprint, which almost doubled from 3.3 gha per person in 1992 to its peak at 6.0 gha per person in 2007 (Figure 7, red line). At this peak, 3.4 planets would have been needed to sustain the world population if everyone on Earth lived like the average Slovenian. However, Slovenia's Ecological Footprint significantly decreased after 2007, and by 2014 Slovenia's Ecological Footprint shrank to 4.7 gha per person.

Slovenia is making great progress toward reducing their Ecological Footprint while maintaining high levels of human development. However, as found in many other EU countries, this trend is partly due to the 2007 economic downturn rather than forward-thinking policies.

The traditional path to development has been resource-intensive, but access to growing levels of ecological resources is no longer guaranteed in today's world. This reality may threaten long-term improvements in human welfare if the conventional path to development is taken. As a country of natural beauty and ecological heritage, Slovenia has maintained the integrity of its ecosystems while simultaneously achieving high levels of well-being for its population. In a resource constrained future, how will the maintenance and protection of natural resources, which are increasingly a source of income through tourism, improve the well-being of Slovenians? Will it be possible for Slovenians to strive for a positive resource balance and achieve better livelihoods within the means of Slovenia's biocapacity?

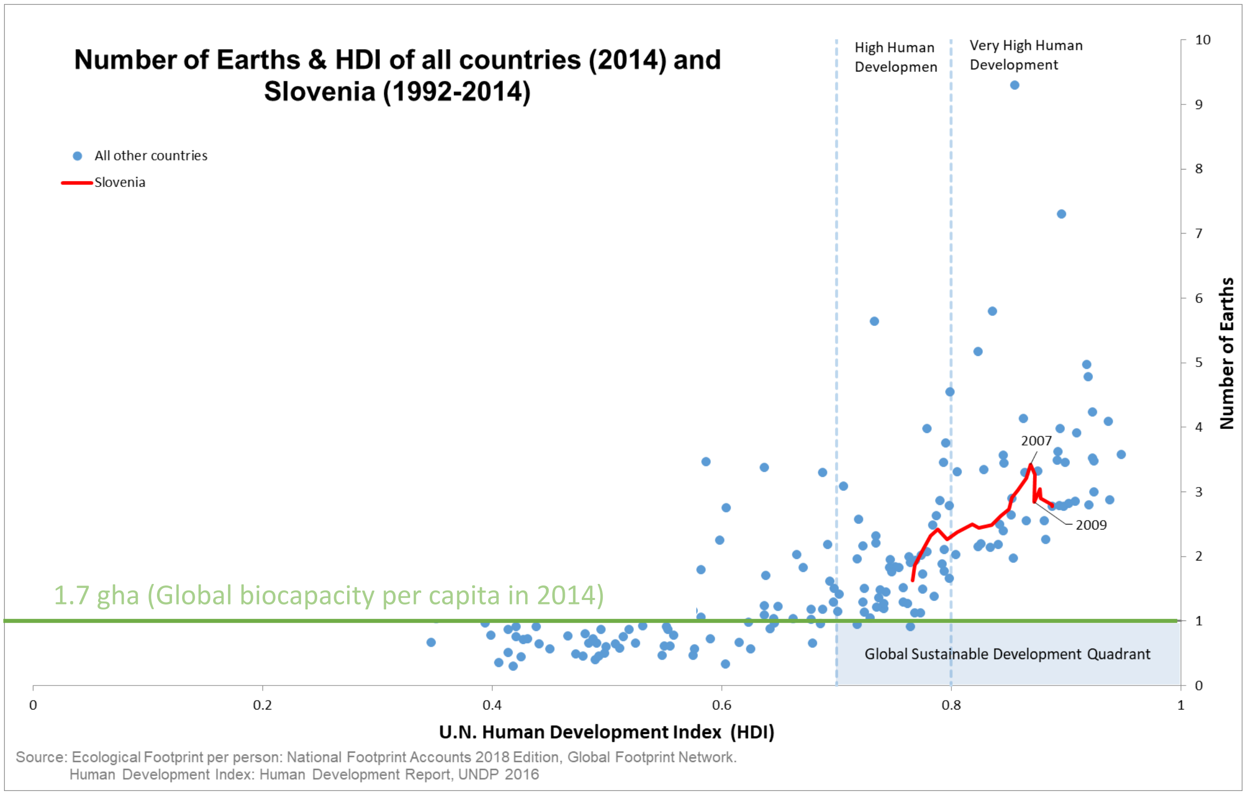

Figure 7: The Ecological Footprint in relation to the Human Development Index of all countries, with Slovenia's time trend for the years 1992 to 2014. The shaded blue box represents the Global Sustainable Development Quadrant, the area where countries have both high levels of human development and replicable globally sustainable resource demands. Ecological Footprint values are represented by 'Number of Earths', a metric that divides the Ecological Footprint of the average citizen of a country by the global biocapacity available to each person in the world, 1.7 gha.

6. How can the Ecological Footprint support Slovenia's National Environmental Action Programme 2030 and Development Strategy 2030?

Slovenia is a country with rich ecological heritage. Historically and today, ecological values are strongly embodied in the culture and psyche of Slovenians. The country is already engaged in a number of sustainable development strategies as it operates within the complex landscape of the EU policies for sustainable development and is already promoting an integrated approach including the SDGs. The Ecological Footprint can thus serve as an additional vehicle and lever to promote sustainable development and implement an integrated approach. It also supports the connection between various dimensions of sustainable development, including competitiveness concerns: used as an indicator by the Slovenia's Development Strategy 2030 and the National Environmental Action Programme 2030, the Ecological Footprint can help these strategies fulfils the role of common frameworks for policy coherence, assessing the progress made towards sustainability by all other actions, policies and strategies implemented within Slovenia.

Fundamental to any sustainability strategy is to recognize the one planet context, and its implications for economic opportunities and human well-being. By offering a clear and simple accounting system, Ecological Footprint can translate the physical context into specific numbers. For instance, it takes the biocapacity of 2 Slovenias to provide the ecosystem services demanded by its residents and nearly 3 planets worth of resources would be needed to support the world population if all people on Earth lived like an average Slovenian. What makes one of the greenest countries in the world run an ecological deficit? This seeming contradiction has a logical explanation and offers opportunities for a productive way forward.

Humanity has reached a point of technological and societal advancement where we have become extremely efficient at harvesting resources and distributing them across the world. For Slovenia, a strong and integrated green culture has helped maintain the integrity and prevented the degradation of the natural systems of the country. However, the excess demand of biocapacity by Slovenians has been met through the import of biocapacity from international trade partners and Slovenia's overuse of the global commons, particularly through import of fossil fuels resulting in CO_2 emissions into the atmosphere.

Undoubtedly, a global market economy and international trade provide great socio-economic benefits to most parties. However, this comes at an environmental cost as global trends indicate both global overshoot and a steadily increasing number of countries in ecological deficit. Because it is impossible for all countries to be net importers of biocapacity to meet their consumption needs, this contradiction is becoming a growing economic risk.

Preliminary recommendations

To strengthen Slovenia’s sustainability and competitiveness efforts, the Ecological Footprint provides a robust accounting tool to ground truth options and assess progress. Ecological Footprint Accounting can thus constitute a complementary, umbrella tool, whose reliability and usefulness for Slovenia’s sustainability efforts can be enhanced through a three-phase process: the “VIA” approach (**v**erification, **i**nterpretation, **a**pplication). “VIA” is the Latin word for “path”. This approach is a sequence of three logical steps.

Step 1: Verification

Before any interpretation or discussion, common understanding needs to be generated about the validity and accuracy of the analysis. To achieve this, a consortium of researchers and government agencies (as representatives of the stakeholders) should test and verify National Footprint Accounts results against nationally-collected data and other relevant assessments they may have available.

Initial interaction with local experts during the training seminar revealed some discrepancies in data[4]. For instance, review of the CLUM indicates a higher housing Footprint than average for high-income countries—even higher than the European average – although a possible explanation for this finding is that Slovenia is one of the least urbanised EU countries with a high number of square meters of housing per inhabitant. Additionally, the forest product footprint comprises an unusually high percent of the

[4] Discrepancies in the data for “Arable land and Permanent crops” area which were noted in the initial meeting have been updated and the results have been recalculated for this report. Initial results used data from CORINE (691,000 hectares) has been updated with FAOSTAT data (215,000). The resulting change did not affect Cropland Ecological Footprint or biocapacity because the production of the Cropland remained the same. Built-up land increased to reflect increased yield factor calculation.

housing Footprint, possibly due to use of timber for parts of construction and firewood for heating. Understanding the underlying causes of this in collaboration with local experts is the first step in identifying reduction opportunities.

Step 2: Interpretation

Once there is consensus that the results are an adequate description of the natural resource status (including agreement on what the accounts measure, how accurate they are, and what their limitations are), only then does it make sense to start interpreting the results. Questions to consider while interpreting the results of Footprint accounting could include:

- What do these trends mean for the competitiveness and sustainable development of the country (or city)?
- How do various stakeholders see these trends shape their country's or city's economic performance? Or the economic performance of their trade partners? Particularly considering the possibility of entering increased global competition for resource access and emission rights.
- What are the implications for different strategies and which strategies have the greatest potential to produce the expected results?

Developing shared interpretations of what makes a country or city's development plan more effective and successful are elemental in applying the tool in decision-making. Closed-door workshops with key stakeholders are a good way to establish consensus around interpretation of the results.

High-level results clearly show that Slovenia is running an ecological deficit. If we assume that the future state of the world will be more limited in resources, one potential direction would be to minimize resource-related risks by addressing ecological deficit– internally through the improvement of resource consumption efficiency and reduction of overall consumption, and externally through the evaluation of trade partners' resource security.

Step 3: Application

Once a governing body has generated a solid, common interpretation of the results, then we can begin to identify a coherent set of actions needed to address the issues surfaced through the analysis. What are the pathways forward, and how should this information affect the decision-making of the country or city? How can options be evaluated? And how do such evaluations enable more successful long-term economic strategies?

After the verification and interpretation steps are complete, Ecological Footprint can be applied in various stages of the policy-making process. To increase the utility of Footprint accounting in guiding policy, it is helpful to identify the steps of the policy-making process that are best informed by Footprint results. We identify five key steps in policy formulation and how Ecological Footprint can inform each of them (Figure 8). Before turning to such analysis, however, it is worth highlighting that an overarching measure of sustainability and ecological impact, Footprint accounting differs from traditional environment and development indicators in that it provides an integrated measure of a national economy's demand for, and the biosphere's supply of, renewable resources and ecosystem services.

As such, the most notable value added brought to the policy discussion by the Ecological Footprint is its capacity to highlight trade-offs between competing human activities, which most of the other resource accounting tools track independently and in isolation. Additionally, the communication simplicity and visual nature of the Footprint make it a powerful medium for communicating the environmental consequences of resource consumption and policies that influence human demand on the planet.

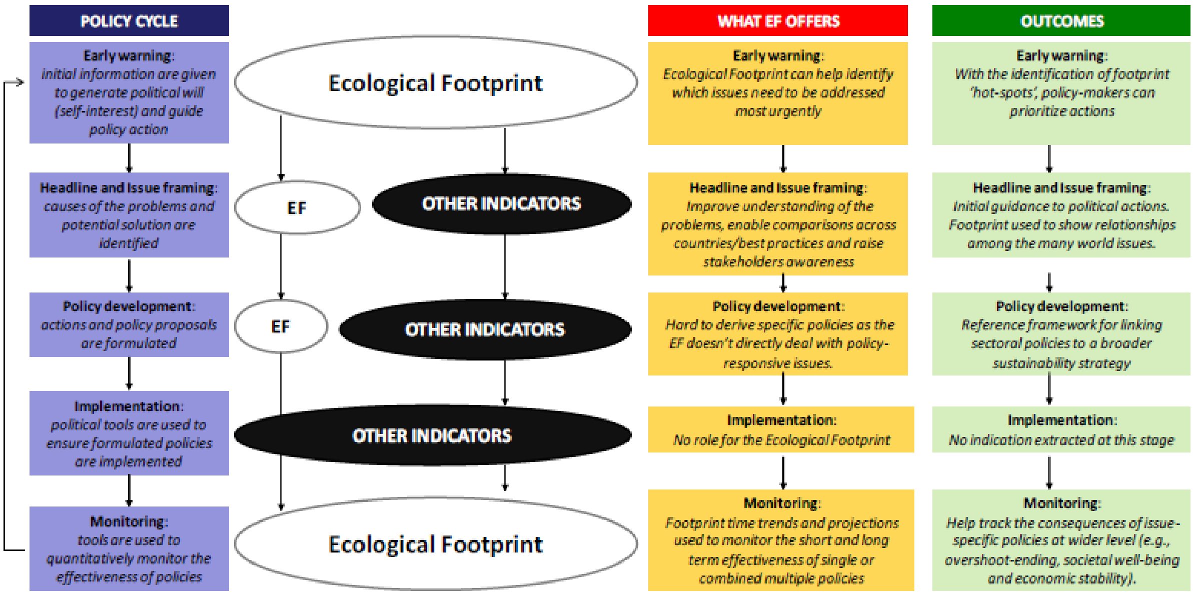

Figure 8: Role and usefulness of the Ecological Footprint in the policy cycle. Source: Galli, 2015

As an "early warning," Footprint results can reinforce holistic and long-term thinking among leaders and stakeholders around resource use and overuse. Results can help identify issues or "hot spots" and guide in the subsequent development of potential interventions and goal setting. As policy is implemented, short-term indicators that relate to specific elements of a given intervention are important supplements to Footprint. Subsequently, Footprint and biocapacity accounting are effective monitoring tools, assessing medium- and long-term outcomes for overall progress toward sustainable development. These applications of Footprint results become even more useful through more detailed trade analysis (using multi-regional input-output modelling) and sector analysis (using a consumption land-use matrix).

Strategy and recommendations

The Ecological Footprint was recently adopted as a Strategic Indicator for the both the Development Strategy 2030 and the National Environmental Action Programme 2030 of Slovenia and, as demonstrated in this report, it can play a guidance role in helping the country measure its overall progress towards the overarching goal of "*a prosperous, high quality of life that is equitably shared and sustainable*" as well as identify intervention hotspots for mitigating the country's Footprint or positively reinforce collective public achievements. For instance, while efforts are already in place in Slovenia to reduce the impact of the housing or transport sectors, policies promoting renewable energy, green building and energy efficiency at home as well as policies promoting sustainable transport options (e.g., investing in zero-emission public transportation, or incentivizing low or zero-emission personal vehicles) are still poorly implemented; Footprint findings (as those shown in Figure 6) could be used to reinforce sectoral prioritization, revamp action and linking sectoral issues back to the broader concept of sustainability. Subsequently, quantitative assessments of various, potential, sector-specific Footprint reductions can be conducted and results jointly interpreted to monitor their combined effect and ensuring they all consistently contribute to sustainable development.

It is thus suggested that further and more detailed modelling analyses and recommendations be developed and delivered in conversation with the Ministry of the Environment and Spatial Planning, Ministry of Agriculture, Forestry and Food, Ministry of Infrastructure, Ministry of Economic Development and Technology, Government Office for Development and European Cohesion Policy, Institute of Macroeconomic Analysis and Development of the Republic of Slovenia, Statistical Office of the Republic of Slovenia, Agricultural Institute of Slovenia, Slovenian Forestry Institute, Energy Efficiency Centre (EEC) from Jožef Stefan Institute, and other governmental agencies, NGOs, and parties participating in the training with Global Footprint Network.

Besides providing relevant values and measures to help monitor the country's progress, the Ecological Footprint can ease the participatory process by framing policy discussion in Slovenia. As past studies have pointed out (e.g., Lehtonen et al., 2016), the use of indicators in decision making processes has thus far almost exclusively focused on the instrumental functions of indicators as malleable governance 'tools', without due attention to the politico-institutional context within which indicators operate. The role of indicators, and even more so of the Ecological Footprint, is not just that of providing dry numbers but rather to influence the approach of their users and the broader political context contributing to a structural change (from *top-down, silo thinking* to *participatory, horizontal, systemic thinking*) in sustainability governance.

An indicator such as the Ecological Footprint can ease powerful processes that can change and steer governance contexts towards sustainable development within certain conditions. The Ecological Footprint has the potential to bring new stakeholders to sustainability debates. Following the above-mentioned VIA approach, it might favour diverse multi-stakeholder gatherings, trigger new institutional arrangements and the creation of new networks as well as that of new communication channels that facilitate learning and steer policy integration horizontally and vertically.

7. Appendix

Appendix 1. Nowcasting Methodology

To estimate Footprint land-use components (cropland, grazing land, forest products, fishing ground, built-up land, and carbon) beyond the latest year of accounting-based data, we use a combination of time-series forecasting models determined to have the lowest prediction error, averaged across all countries, compared to a multitude of other techniques. The selected method applies an equally-weighted ensemble forecast for each land-type, consisting of non-seasonal exponential smoothing (ETS) and an auto-regressive integrated moving average (ARIMA) with GDP per capita (in fixed USD) as an external regressor.

For the non-carbon Footprint components, we apply the ensemble model to per capita Ecological Footprint of consumption (EF). For carbon EF, we model production (EFp), and trade (EFi, EFe) separately because reported CO_2 production data is generally available for more recent data years compared to other datasets. In the case where CO_2 emissions data exists as the only dataset available for a certain year, the carbon Footprint of production is first scaled, according to the annual change in CO_2 production emissions, to the latest year of reported data before applying the ensemble model.

For both carbon and non-carbon land-use component Footprint forecasts, associated confidence intervals are calculated from individual model forecasts and combining them with the root of a weighted sum of squares. The weights in this calculation are the square of the maximum likelihood estimates associated with each model. For biocapacity estimates, we use ordinary least squares (OLS) model forecasts to establish confidence intervals. To forecast biocapacity land-type components, we use an OLS linear regression model based on the per capita biocapacity of the most recent ten years of data.

Appendix 2. Multi-Regional Input-Output Footprint Accounts (MRIO-FA) Methodology

To track the contribution of economic activity to demands on the biosphere, specific data and analytical methods are needed to identify demands and allocate them to the various economic activities.

For this report, we use Global Trade Analysis Project (GTAP)-based Environmentally-Extended Multi-Regional Input-Output analysis (EE-MRIO). The multi-regional feature is needed because modern economies are deeply embedded in import and export flows. It is environmentally extended, because standard Input-Output models track financial flows. By extending them, we overlay these financial flows with the associated resources.

GTAP is one of the most comprehensive global models available, and the strongest one for analysis that includes biological resources. Even though the model is limited to 57 sectors, many of them are within the agricultural or forestry domain, making it particularly suitable for Ecological Footprint analyses. With 57 sector types and 140 regions, GTAP provides an input-output table of 7,980 unique sectors, all of which are inter-related through direct or indirect monetary flows.

For the environmental extension, we use Ecological Footprint. This information is derived from the Global Footprint Network's National Footprint Accounts, 2018 edition. We call this combination of GTAP's MRIO and Global Footprint Network's National Footprint Accounts, MRIO-FA (standing for MRIO Footprint Accounts). We use our MRIO-FA model to generate the Footprint intensities associated with economic sectors and consumer spending. The MRIO-FA model uses financial data on purchases between sectors of the economy and purchases by final consumers as a proxy for flows of embodied resources.

EE-MRIO analysis allows for analyzing trade from two distinct perspectives, which are referred to in the MRIO-FA model as "direct trade" and "origin-destination." Direct trade captures the Footprint embodied in an actual transaction, where a sector sells goods or services to another sector or to a final consumer. Origin-destination trade captures the connection between where Footprint was originally generated and where that Footprint was finally consumed.

For example, if the cotton growing industry in Brazil sells raw cotton to the textile manufacturing industry in Vietnam, the embodied cropland Footprint in the cotton would be counted as a direct export to Vietnam. The Vietnam textile industry can then use that cotton to produce cotton fabric, which it could sell to the clothing manufacturing sector in Vietnam. Since the fabric stays within Vietnam, this sale is not counted as trade, though it does carry embodied cropland Footprint from the cotton as well as embodied carbon Footprint from emissions generated in the manufacturing process. The clothing sector in Vietnam then turns the cotton fabric into clothing, which it could export to retail clothing stores in Slovenia. This direct export to the retail sector in Slovenia would carry embodied cropland Footprint as well as carbon Footprint from the entire manufacturing process. When the final consumer, a shopper at the store in Slovenia, purchases the clothing, they are consuming the entire Footprint of this long chain, from the cropland in Brazil, to the emissions from the manufacturing sectors in Vietnam, the emissions from transporting the goods, and the energy use of the retail stores in Slovenia. All along the way, Footprint was imported and exported again, while more Footprint was being generated by the activities of each sector.

Direct trade occurs each time a product crosses borders, and the Footprint of that trade captures the entire embodied resource use of that product. Direct trade analysis would show Brazil exporting cropland Footprint to Vietnam, and Vietnam exporting both cropland and carbon Footprint to Slovenia.

Origin-destination analysis, however, would show the situation differently. Origin-destination would show Brazil 'exporting' cropland Footprint to the final consumer in Slovenia, and Vietnam 'exporting' carbon Footprint to the final consumer.

Appendix 3. Consumption Land Use Matrix (CLUM) Methodology

The CLUM calculates the Ecological Footprint associated with purchases in major consumption categories. A CLUM is unique to the economic system of a country, and can often highlight surprising findings that reveal important underlying features of a nation's consumption and its impact on ecological systems.

CLUMs are also used as reference points. The national CLUM describes consumption pattern at the national level. By using data that compares national average consumption in various categories with local consumption, an estimate of a local CLUM can be calculated. This approach is used for estimating the consumption Footprint of sub-national populations, for example cities or states.

The most common way to generate CLUMs is to use environmentally-extended input-output (IO) models—tying consumption also to expenditure categories. See Appendix 2 for more discussion on environmentally extended input-output analysis.

Within the CLUM, there are two broad classifications:

1. Areas that are under direct short-term influence by households, such as direct consumption under the broad categories of food, shelter, personal transportation, goods, and services.
2. Areas that are under long-term or indirect influence by households, such as capital investment and infrastructure and government expenditure.

In the MRIO-FA model, capital investment and infrastructure come from investments by firms (e.g., new factories and machinery). Government consumption is the ongoing consumption associated with the functions of the government, some of which might directly and materially benefit households.

Within the areas of direct short-term influence, the top level row categories are: food, housing, mobility (or personal transportation), goods, and services. Each top-level category is further broken down into sub-categories given by Classification of Individual Consumption According to Purpose (COICOP) classifications established by the United Nations.

The columns list each land use type and the total, therefore each cell refers to the Ecological Footprint on a certain land use type resulting from final purchases falling under each consumption category. For example, the grazing land Footprint associated with food purchases is 0.10 gha per capita.

Appendix 4. Consumption Land Use Matrix (CLUM) Results

Table A4.1. Per capita Consumption Land Use Matrix (CLUM) for Slovenia; data year 2014.

	Household							Government	Fixed Capital Formation	TOTAL
[gha person^{-1}]	Cropland	Grazing Land	Forest Products	Fishing Grounds	Built-up Land	Carbon	HH SUB TOTAL			
Food	0.36	0.08	0.03	0.02	0.00	0.14	0.64	0.00	0.03	0.67
Housing	0.02	0.01	0.39	0.00	0.00	0.80	1.23	0.11	0.49	1.83
Personal Transp	0.03	0.01	0.07	0.00	0.00	0.57	0.69	0.01	0.11	0.81
Goods	0.08	0.04	0.15	0.01	0.00	0.27	0.54	0.01	0.08	0.63
Services	0.03	0.01	0.05	0.00	0.00	0.18	0.28	0.40	0.06	0.75
Total	0.53	0.14	0.69	0.04	0.01	1.98	3.38	0.53	0.77	4.68

Appendix 5. Glossary of Terms

Biological capacity or biocapacity: The capacity of ecosystems to regenerate what people demand from those surfaces. Life, including human life, competes for space. The biocapacity of a particular surface represents its ability to renew what people demand. Biocapacity is therefore the ecosystems' capacity to produce biological materials used by people and to absorb waste material generated by humans, under current management schemes and extraction technologies. Biocapacity can change from year to year due to climate, management, and also what portions are considered useful inputs to the human economy. In the National Footprint Accounts, the biocapacity of an area is calculated by multiplying the actual physical area by the yield factor and the appropriate equivalence factor. Biocapacity is expressed in global hectares.

Biological capacity available per person (*or* per capita): There were about 12 billion hectares of biologically productive land and water on Earth in 2012. Dividing by the number of people alive in that year (7.1 billion) gives 1.73 global hectares per person. This area also needs to accommodate the wild species that compete for the same biological material and spaces as humans.

Biologically productive land and water: The land and water (both marine and inland water) area that supports significant photosynthetic activity and the accumulation of biomass used by humans. Non-productive areas as well as marginal areas with patchy vegetation are not included. Biomass that is not of use to humans is also not included. The total biologically productive area on land and water in 2011 was approximately 12 billion hectares.

Carbon Footprint: The carbon Footprint measures CO_2 emissions associated with fossil fuel use. In Ecological Footprint accounts, these amounts are converted into biologically productive areas necessary for absorbing this CO_2. The carbon Footprint is added to the Ecological Footprint because it is a competing use of bioproductive space, since increasing CO_2 concentrations in the atmosphere is considered to represent a build-up of ecological debt. Some carbon Footprint assessments express results in tonnes released per year, without translating this amount into area needed to sequester them.

Consumption: Use of goods or of services. The term consumption has two different meanings, depending on context. As commonly used in regard to the Footprint, it refers to the use of goods or services. A consumed good or service embodies all the resources, including energy, necessary to provide it to the consumer. In full life-cycle accounting, everything used along the production chain is taken into account, including any losses along the way. For example, consumed food includes not only the plant or animal matter people eat or waste in the household, but also that lost during processing or harvest, and all the energy used to grow, harvest, process and transport the food.

As used in input-output analysis, consumption has a strict technical meaning. Two types of consumption are distinguished: intermediate and final. According to (economic) System of National Accounts terminology, intermediate consumption refers to the use of goods and services by a business in providing goods and services to other businesses. Final consumption refers to non-productive use of goods and services by households, the government, the capital sector, and foreign entities.

Consumption components (also consumption categories): Ecological Footprint analyses can allocate total Footprint among consumption components, typically Food, Housing, Mobility, Goods, and Services--often with further resolution into sub-components. Consistent categorization across studies allows for comparison of the Footprint of individual consumption components across regions, and the relative contribution of each category to the region's overall Footprint. To avoid double counting, it is important to make sure that consumables are allocated to only one component or sub-component. For example, a refrigerator might be included in either the food, goods, or shelter component, but only in one.

Consumption Land Use Matrix: Starting with data from the National Footprint Accounts, a Consumption Land Use Matrix allocates the six major Footprint land uses (shown in column headings) allocated to the five basic consumption components (row headings). For additional resolution, each consumption component can be disaggregated further. These matrices are often used as a starting point for sub-national (e.g. state, county, city) Footprint assessments. In this case, national data for each cell is scaled up or down depending on the unique consumption patterns in that sub-national region compared to the national average.

Ecological deficit / reserve (or biocapacity reserve / deficit): The difference between the biocapacity and Ecological Footprint of a region or country. An ecological deficit occurs when the Footprint of a population exceeds the biocapacity of the area available to that population. Conversely, an ecological reserve exists when the biocapacity of a region exceeds its population's Footprint. If there is a regional or national ecological deficit, it means that the region is importing biocapacity through trade or liquidating regional ecological assets, or emitting wastes into the global commons such as the atmosphere. In contrast to the national scale, the global ecological deficit cannot be compensated for through trade, and is therefore equal to overshoot by definition.

Ecological Footprint: A measure of how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices. The Ecological Footprint is usually measured in global hectares. Because trade is global, an individual or country's Footprint includes land or sea from all over the world. Without further specification, Ecological Footprint generally refers to the Ecological Footprint of consumption. Ecological Footprint is often referred to in short form as Footprint. "Ecological Footprint" and "Footprint" are proper nouns and thus should always be capitalized.

Equivalence factor: A productivity--based scaling factor that converts a specific land type (such as cropland or forest) into a universal unit of biologically productive area, a global hectare. For land types (e.g., cropland) with productivity higher than the average productivity of all biologically productive land and water area on Earth, the equivalence factor is greater than 1. Thus, to convert an average hectare of cropland to global hectares, it is multiplied by the cropland equivalence factor of 2.53. Grazing lands, which have lower productivity than cropland, have an equivalence factor of 0.45 (see also yield factor). In a given year, equivalence factors are the same for all countries.

Global hectare (gha): Global hectares are the accounting unit for Ecological Footprint and biocapacity accounts. These productivity-weighted **biologically productive hectares** allow researchers to report both the biocapacity of the earth or a region, and the demand on biocapacity (the Ecological Footprint). A global hectare is a biologically productive hectare with world average biological productivity for a given year. Global hectares are needed because different land types have different productivity. A global hectare of, for example, cropland, would occupy a smaller physical area than the much less biologically productive pasture land, as more pasture would be needed to provide the same biocapacity as one hectare of cropland. Because world bioproductivity varies slightly from year to year, the value of a gha may change slightly from year to year.

National Footprint Accounts: The central dataset that calculates Footprint and biocapacity of the world and more than 200 nations from 1961 to the present (generally with a three-year lag due to data availability). The ongoing development, maintenance and upgrades of the National Footprint Accounts are coordinated by Global Footprint Network and its partners.

Yield: The amount of regenerated primary product, usually reported in tons per year, that humans are able to extract per area unit of biologically productive land or water.

Yield factor: A factor that accounts for differences between countries in productivity of a given land type. Each country and each year has yield factors for cropland, grazing land, forest, and fisheries. For example, in 2012, Hungarian cropland was 0.95 times as productive than world average cropland. The Hungarian cropland yield factor of 0.95, multiplied by the cropland equivalence factor of 2.53 converts Hungarian cropland hectares into global hectares: one hectare of cropland is equal to 2.41 gha.

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